1½"

GLOSSARY OF TERMS

ELECTRICAL ACCURACY is the ability of an instrument to indicate at the division line being checked when energized by the corresponding rated value of excitation, plus or minus the product of the accuracy rating times the full scale rated value.

EXAMPLE

An instrument having a rated excitation for full scale of 100 microampere has an actual excitation of 41 microamperes at the 40 microampere point. The electrical accuracy error is $\left(\frac{40-41}{100}\right) 100 = -1\%$.

TRACKING ACCURACY is the ability of an instrument to indicate at the division line being checked when energized by corresponding proportionate value of actual full scale current or voltage plus or minus the product of the accuracy rating times the full scale actual value. A proportionate value is defined as the product of the actual current or voltage required to deflect the pointer to the full scale division line times the ratio of the rated scale value being checked to the rated full scale value of the instrument.

EXAMPLE

A 1 MA instrument is tested for tracking accuracy by placing it in series with a resistor dial box. With 100 volts applied to the combination, the dial box is adjusted so that the pointer of the instrument under test reads exactly full scale. The excitation is now decreased so that the pointer reads .9 MA and the standard reads 91 volts. Thus, the instrument under test has a 1% tracking accuracy at the .9 MA point.

BALANCE is a condition wherein the indication of the pointer on the scale changes due to placing the instrument in various positions.

DAMPING FACTOR is the ratio of the deviations of the pointer in two consecutive swings from the position of equilibrium, the greater deviation being divided by the lesser. It is the reciprocal of overswing.

EXAMPLE

If the maximum momentary deflection is 90° and the steady deflection is 75°, the difference between the two is 15° and the damping factor (the ratio of 75° to 15°) is 5.

OVERSHOOT OR OVERSWING is the ratio of the overtravel of the pointer beyond a steady deflection to the steady deflection when a new constant value of the measured quantity is suddenly applied. Overshoot and damping factor have a reciprocal relationship.

EXAMPLE

The pointer of an instrument has a momentary deflection to 100° and has a steady deflection of 80°.

$$\%\ \text{O.S.} = \left(\frac{100-80}{80}\right) 100 = \left(\frac{20}{80}\right) 100 = 25\%$$

If the overswing requirement is given for a certain circuit resistance, the instrument should be tested for overswing with that resistance in series with the instrument. Otherwise, the instrument should be tested for overshoot in a circuit of at least 100 times the resistance of the instrument under test. Not applicable to voltmeters.

RESPONSE TIME is the time required until the pointer has first come to apparent rest, after an abrupt change in excitation to a new constant value has occurred.

If a response time requirement is given for a certain circuit resistance, the instrument should be tested for response time with that resistance in series with the instrument. Otherwise, the instrument should be tested for response time in a circuit of at least 100 times the resistance of the instrument under test.

REPEATABILITY ACCURACY is the ability of an instrument to repeat its readings taken when deflecting the pointer upscale by the reading taken when deflecting the pointer downscale, expressed as a percentage of the rated full scale value.

EXAMPLE

At the division line closest to ½ scale a 100 microampere instrument needs 51 microamperes to accomplish upscale deflection and only 49 microamperes to accomplish downscale deflection.

$$\text{Repeatability} = \left(\frac{51-49}{100}\right) 100 = 2\%$$

CREEP is the change in pointer deflection with time with a known constant current applied.

STICKINESS is a condition caused by physical interference with the rotation of the moving element.

FULL SCALE SENSITIVITY is the actual excitation required for full scale deflection.

EXAMPLE

An instrument has a rated full scale sensitivity of 100 microamperes but the actual full scale sensitivity is 101 microamperes.

The sensitivity error is

$$\left(\frac{I_R - I_A}{I_R}\right) 100 = \left(\frac{100-101}{100}\right) 100 = 1\%$$

INSULATION RESISTANCE is the resistance offered by the insulating members of an instrument part to an impressed direct voltage tending to produce a leakage of current through or on the surface of these members.

DIELECTRIC WITHSTANDING VOLTAGE is the application of voltage between all external live parts of the instrument and the exposed metal parts on the front of the instrument, and the metal panel on which the instrument is mounted.

STATIC CHARGE INFLUENCE is deflection of the instrument pointer caused by external forces due to static acting on the moving element.

EXTERNAL TEMPERATURE INFLUENCE is the percentage change of full scale value in the indication of an instrument that is caused solely by a difference in ambient temperature from the reference temperature.

FREQUENCY INFLUENCE is the percent change of full scale value in the indication of an instrument that is caused solely by a frequency departure from a specified reference frequency.

Frequency influence is applicable only to instruments other than frequency meters.

CONVERSION FACTORS, FORMULAS, TABLES (Cont.)

Conversion Factors and Constants

$\pi = 3.14$ $\quad 2\pi = 6.28$

$\pi^2 = 9.87$ $\quad (2\pi)^2 = 39.5$

$\epsilon = 2.718$ $\quad \sqrt{2} = 1.414$

$\sqrt{3} = 1.732$ $\quad \log \pi = 0.497$

1 meter = 39.37 inches = 3.28 feet
1 kilometer = 0.621 mile (about 3/5 mile)
1 inch = 2.54 centimeters
1 kilogram = 2.2 pounds
1 liter = 1.06 quarts
1 ounce = 28.35 grams
1 horsepower = 746 watts

Ohm's Law Formulas for D-C Circuits

$$I = \frac{E}{R} = \sqrt{\frac{P}{R}} = \frac{P}{E} \qquad R = \frac{E}{I} = \frac{P}{I^2} = \frac{E^2}{P}$$

$$E = IR = \frac{P}{I} = \sqrt{PR} \qquad P = I^2R = EI = \frac{E^2}{R}$$

Ohm's Law Formulas for A-C Circuits

In these formulas θ is the angle of lead or lag between current and voltage and $\cos\theta = P/EI$ = power factor.

$$I = \frac{E}{Z} = \sqrt{\frac{P}{Z\cos\theta}} = \frac{P}{E\cos\theta}$$

$$E = IZ = \frac{P}{I\cos\theta} = \sqrt{\frac{PZ}{\cos\theta}}$$

$$Z = \frac{E}{I} = \frac{P}{I^2\cos\theta} = \frac{E^2\cos\theta}{P}$$

$$P = I^2Z\cos\theta = IE\cos\theta = \frac{E^2\cos\theta}{Z}$$

Resistors in Series

$$R_{total} = R_1 + R_2 + R_3 + \cdots$$

Two Resistors in Parallel

$$R_t = \frac{R_1R_2}{R_1 + R_2} \qquad R_1 = \frac{R_tR_2}{R_2 - R_t}$$

Equal Resistors in Parallel

$R_{total} = \frac{R}{n}$, where n is the number of resistors

Resistors in Parallel, General Formula

$$R_{total} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots}$$

Sinusoidal Voltages and Currents

Effective value = 0.707 × peak value
Average value = 0.637 × peak value
Peak value = 1.414 × effective value
Effective value = 1.11 × average value
Peak value = 1.57 × average value
Average value = 0.9 × effective value

Conductance, Susceptance, and Admittance

$$G = \frac{1}{R} \text{ (for D-C circuit)}$$

$$G = \frac{R}{R^2 + X^2} \text{ (for A-C circuit)}$$

$$B = \frac{1}{X} \text{ (when resistance is 0)}$$

$$B = \frac{X}{R^2 + X^2}$$

$$Y = \frac{1}{Z} = \frac{1}{\sqrt{R^2 + X^2}}$$

Reactance Formulas

$$X_C = \frac{1}{2\pi fC} \qquad C = \frac{1}{2\pi fX_C}$$

$$X_L = 2\pi fL \qquad L = \frac{X_L}{2\pi f}$$

Resonant Frequency Formulas

$$f = \frac{1}{2\pi\sqrt{LC}}, \text{ or } f = \frac{159.2^*}{\sqrt{LC}}$$

$$L = \frac{1}{4\pi^2f^2C}, \text{ or } L = \frac{25{,}330^*}{f^2C}$$

$$C = \frac{1}{4\pi^2f^2L}, \text{ or } C = \frac{25{,}330^*}{f^2L}$$

*where in the second formula f is in kc and L and C are in microunits.

Impedance Formulas

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \text{ (for series circuit)}$$

$$Z = \frac{RX}{\sqrt{R^2 + X^2}} \text{ (for R and X in Parallel)}$$

Power Factor

pf = $\cos\theta$, where θ is the angle of lead or lag

$$pf = \frac{\text{true power}}{\text{apparent power}} = \frac{P}{EI}$$

$$pf = \frac{R}{Z}$$

Q or Figure of Merit

$$Q = \frac{X_L}{R} \text{ or } \frac{X_C}{R}$$

Transformer Relationships

$$\frac{N_P}{N_S} = \frac{E_P}{E_S} = \frac{I_S}{I_P} = \sqrt{\frac{Z_P}{Z_S}}$$

Efficiency (for any device)

$$\text{Eff} = \frac{\text{output}}{\text{input}}$$

Decibel Formulas

When impedances are equal,

$$db = 10\log\frac{P_1}{P_2} = 20\log\frac{E_1}{E_2} = 20\log\frac{I_1}{I_2}$$

When impedances are unequal,

$$db = 10\log\frac{P_1}{P_2} = 20\log\frac{E_1\sqrt{Z_2}}{E_2\sqrt{Z_1}} = 20\log\frac{I_1\sqrt{Z_1}}{I_2\sqrt{Z_2}}$$

DECIBEL TABLE

DB	Power Ratio	Voltage or Current Ratio	DB	Power Ratio	Voltage or Current Ratio
0	1.00	1.00	10	10.0	3.2
0.5	1.12	1.06	15	31.6	5.6
1.0	1.26	1.12	20	100	10
1.5	1.41	1.19	25	316	18
2.0	1.58	1.26	30	1,000	32
3.0	2.00	1.41	40	10,000	100
4.0	2.51	1.58	50	10^5	316
5.0	3.16	1.78	60	10^6	1,000
6.0	3.98	2.00	70	10^7	3,162
7.0	5.01	2.24	80	10^8	10,000
8.0	6.31	2.51	90	10^9	31,620
9.0	7.94	2.82	100	10^{10}	10^5

Frequency and Wavelength

$$f_{kc} = \frac{3\times10^5}{\lambda_{meter}} \qquad \lambda_{meter} = \frac{3\times10^5}{f_{kc}}$$

$$f_{Mc} = \frac{3\times10^4}{\lambda_{centimeter}} \qquad \lambda_{cm} = \frac{3\times10^4}{f_{Mc}}$$

$$f_{Mc} = \frac{984}{\lambda_{feet}} \qquad \lambda_{feet} = \frac{984}{f_{Mc}}$$

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